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DEPARTMENT OF THE NAVY

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CAVITATION TESTS OF ESCORT RESEARCH VESSEL COUNTERROTATING PROPELLERS 3808 AND 3809 IN SIMULATED WAKE

by

James G. Peck

HYDROMECHANICS LABORATORY
TEST EVALUATION REPORT

March 1963

Report 1731

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NOTATION

D	Diameter of propeller
D_F	Diameter of forward propeller
e	Efficiency, $\dfrac{(T_F + T_A)\, V_a}{2\pi(Q_F + Q_A)\, n}$
g	Acceleration due to gravity
H	Absolute static pressure at shaft centerline minus the vapor pressure
J	Speed coefficient $\dfrac{V_a}{nD_F}$
K_{tA}	Thrust coefficient of after propeller, $\dfrac{T_A}{\rho\, n^2 D_F^{\,4}}$
K_{tF}	Thrust coefficient of forward propeller , $\dfrac{T_A}{\rho\, n^2 D_F^{\,4}}$
K_{tT}	Total thrust coefficient, $\dfrac{T_F + T_A}{\rho\, n^2\, D_F^{\,4}}$
K_{qA}	Torque coefficient of after propeller, $\dfrac{Q_A}{\rho\, n^2\, D_F^{\,5}}$
K_{qF}	Torque coefficient of forward propeller, $\dfrac{Q_F}{\rho\, n^2\, D_F^{\,5}}$
K_{qT}	Total torque coefficient, $\dfrac{Q_F + Q_A}{\rho\, n^2\, D_F^{\,5}}$
n	Revolutions per unit time
Q_A	Torque on after propeller
Q_F	Torque on forward propeller
r	Radial coordinate of propeller
R	Propeller radius
T_A	Thrust on after propeller

T_F	Thrust on forward propeller
V	Tunnel reference velocity
V_a	Speed of advance
w	Effective wake fraction, $1 - \frac{V_a}{V}$
ρ	Density of water
σ	Cavitation index, $\frac{2gH}{V_a^2}$

ABSTRACT

A pair of counterrotating propellers, designed for the Escort Research Vessel, were tested in the TMB variable pressure water tunnel. Cavitation characteristics of the pair operating in a wake are presented. Cavitation inception curves, open-water characteristics and sketches of the cavitation are included.

INTRODUCTION

As part of a continuing research program a set of counterrotating propellers, designed for the Escort Research Vessel, were built and tested in open water and in the 24-inch variable pressure water tunnel at the David Taylor Model Basin.* The forward propeller was designated TMB 3808 and the after propeller was designated TMB 3809. The drawings and design characteristics of these propellers are shown in Figures 1 and 2.

PROCEDURE

Open-water tests were conducted in the TMB deep-water basin. The propellers were mounted on concentric shafts, and the thrust and torque were measured on each shaft using counterrotating transmission dynamometers. The tests were run from 7.0 to 10.0 rps over a speed range of 3.0 to 12.1 fps, which resulted in Reynolds numbers from 319 x 10^5 to 6.4 x 10^5.

Cavitation tests of the modal counterrotating propellers were conducted in the 24-inch water tunnel equipped with a wake producer. The forward propeller was mounted on the upstream shaft and the thrust, torque, and rpm were measured on the 4-horsepower dynamometer. The after propeller was mounted on the downstream shaft and the thrust, torque, and rpm were measured on the 10-horsepower dynamometer.

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* BuShips ltr AG/S44(644) Ser 644-342 of 12 June 1959 to DTMB.

The wake producer was mounted on the upstream shaft housing, and the radial distribution of the wake was measured with a pitot tube. The wake producer was adjusted until a radial distribution of the wake similar to that of the Escort Research Vessel model was obtained. A comparison of the simulated tunnel wake with the model wake is shown in Figure 3.

The tunnel reference velocity V was measured with a pitot tube located 10 inches from the shaft centerline in the plane of the forward propeller. Pitot tube calibration tests were run, at atmospheric pressure, in which the speed of advance V_a of the propellers was established on the basis of K_{tT} identity with the open-water tests. The total thrust produced by both propellers at equal rpm determined K_{tT}. The reference velocity is related to the speed of advance by the expression $V = \frac{V_a}{1-w}$. The speed of advance was used for all computations.

The cavitation inception tests were conducted over a range of speed coefficients J from 0.90 to 1.44, obtained by varying the rpm from 695 to 1008 at speeds of advance of 12 and 14 fps. The Reynolds numbers of these tests varied from 7.7×10^5 to 9.6×10^5. At each speed coefficient the cavitation index σ was varied by changing the tunnel pressure. Starting in a noncavitating condition, the tunnel pressure was reduced until cavitation appeared or the cavitation pattern changed. For each speed coefficient, at various cavitation indices, the thrust, torque, and pressure were recorded and sketches of the location of face, back, and tip-vortex cavitation made.

RESULTS

The open-water characteristic curves of model counterrotating propellers 3808 and 3809 are presented in Figure 4, and the inception curves of visible cavitation are shown in Figure 5. The curves in Figure 5 represent the limiting value of cavitation index for inception of the type of cavitation present. Below the curves the intensity of cavitation increases as the cavitation index decreases. At a given speed coefficient and cavitation index, the type of cavitation present may be determined from the curves above this point on the chart.

The thrust and torque coefficients were calculated and plotted against cavitation index, for constant speed coefficients, in Figures 6 and 7. Sketches of visual observations of the cavitation present, at selected values of cavitation index, for the speed coefficients tested are shown in Figures 8 and 9.

NUMBER OF BLADES............	4	DIAMETER.....................	10.000 Ins.
EXP.AREA RATIO..............	0.594	PITCH (AT 0.7R).............	15.205 Ins.
MWR.........................	0.317	DESIGNED ROTATION...........	L.H.
BTF.........................	0.044	TESTED FOR.......	BUSHIPS
P/D (AT 0.7R)...............	1.520	DESIGNED BY......	BUSHIPS

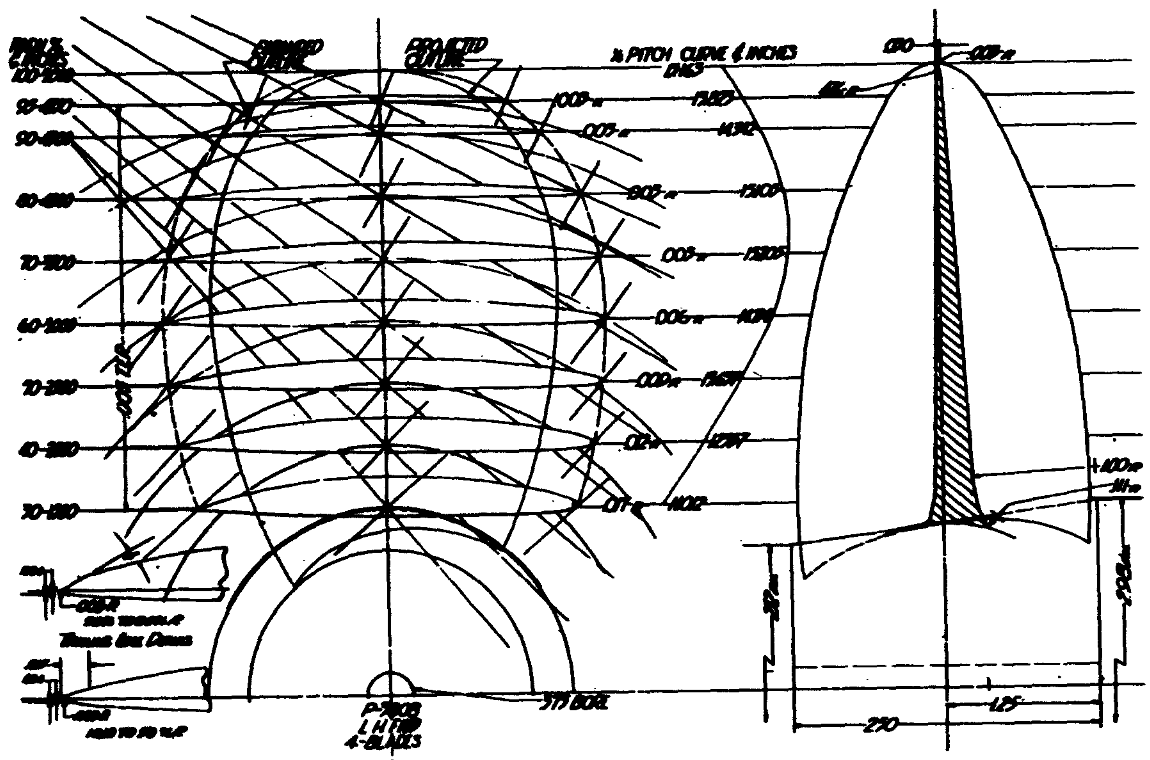


Figure 1 - Drawing of Model Propeller 3808

NUMBER OF BLADES	5	DIAMETER	9.643 Ins.
EXP.AREA RATIO	0.615	PITCH (AT 0.7R)	14.018 Ins.
MWR	0.236	DESIGNED ROTATION	R.H.
BTF	0.046	TESTED FOR	BUSHIPS
P/D (AT 0.7R)	1.454	DESIGNED BY	BUSHIPS

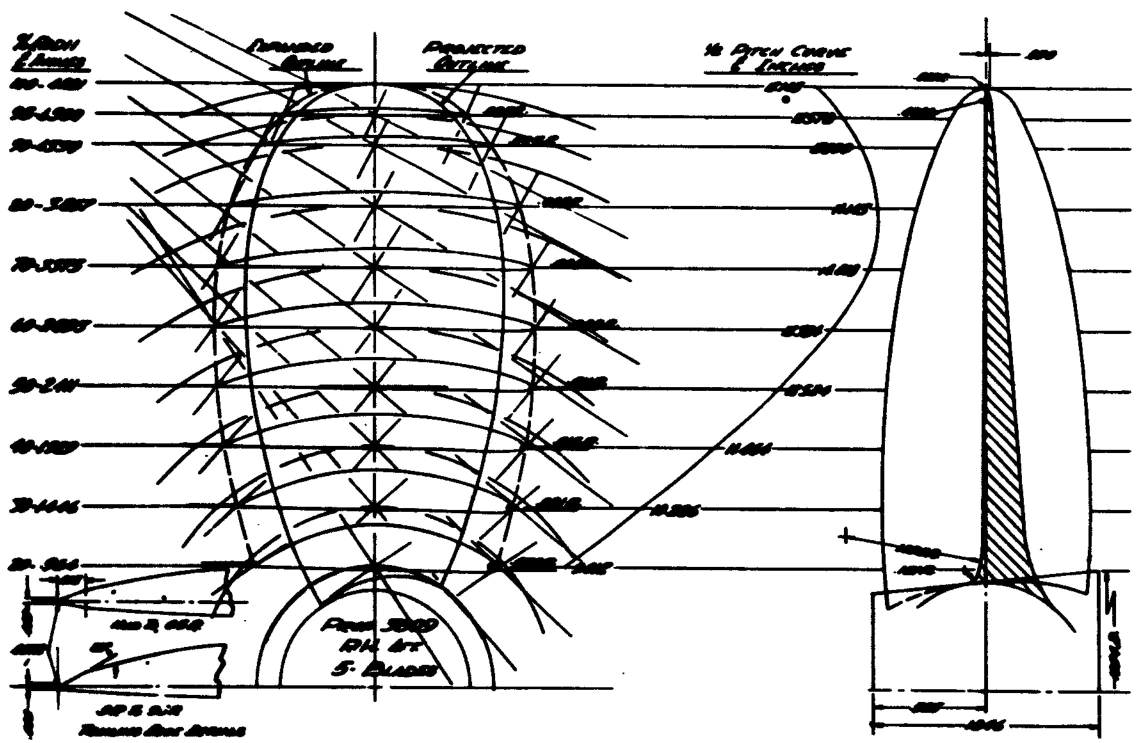


Figure 2 - Drawing of Model Propeller 3809

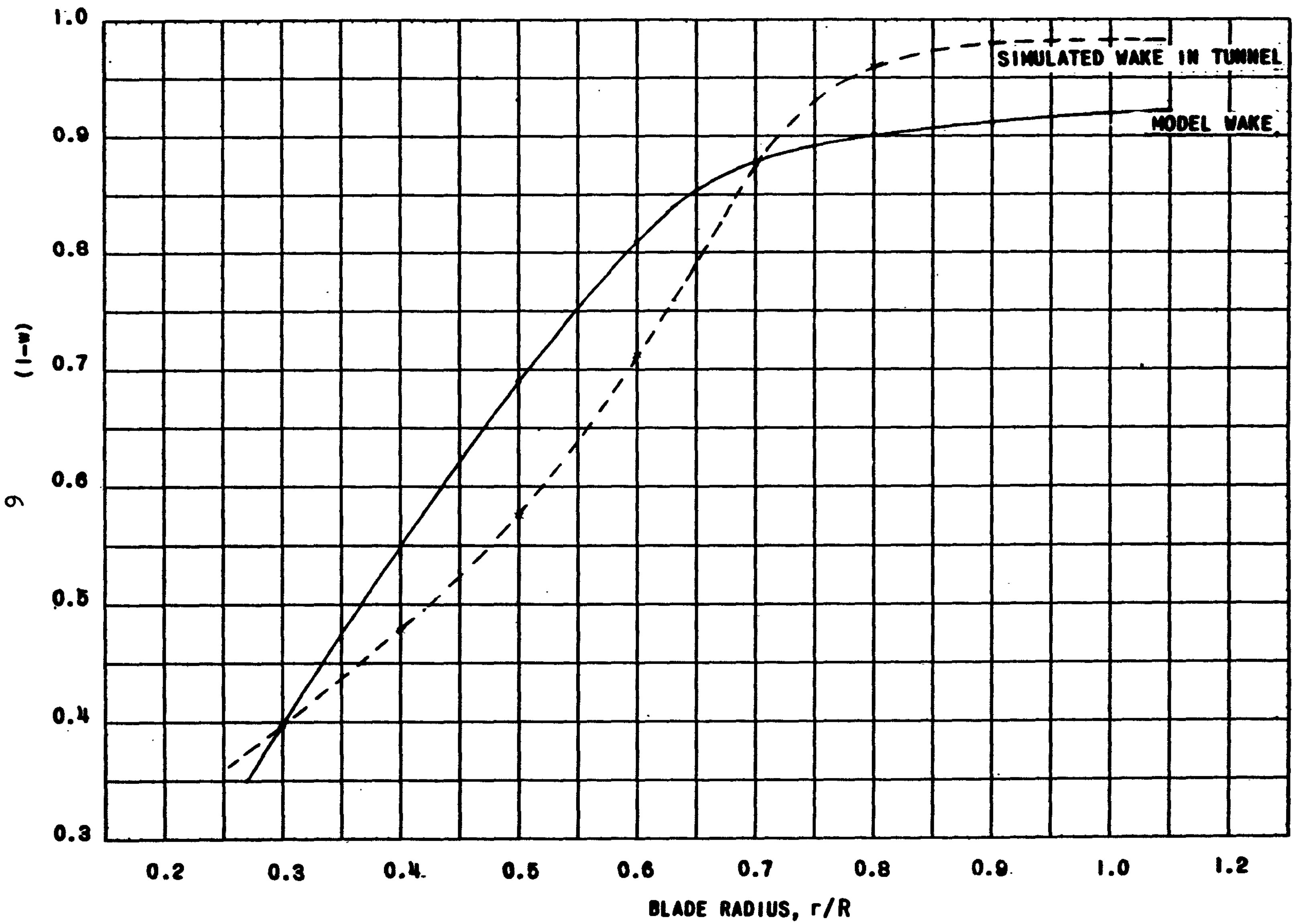


Figure 3 - Comparison of Simulated Tunnel Wake with Escort Research Vessel Model Wake

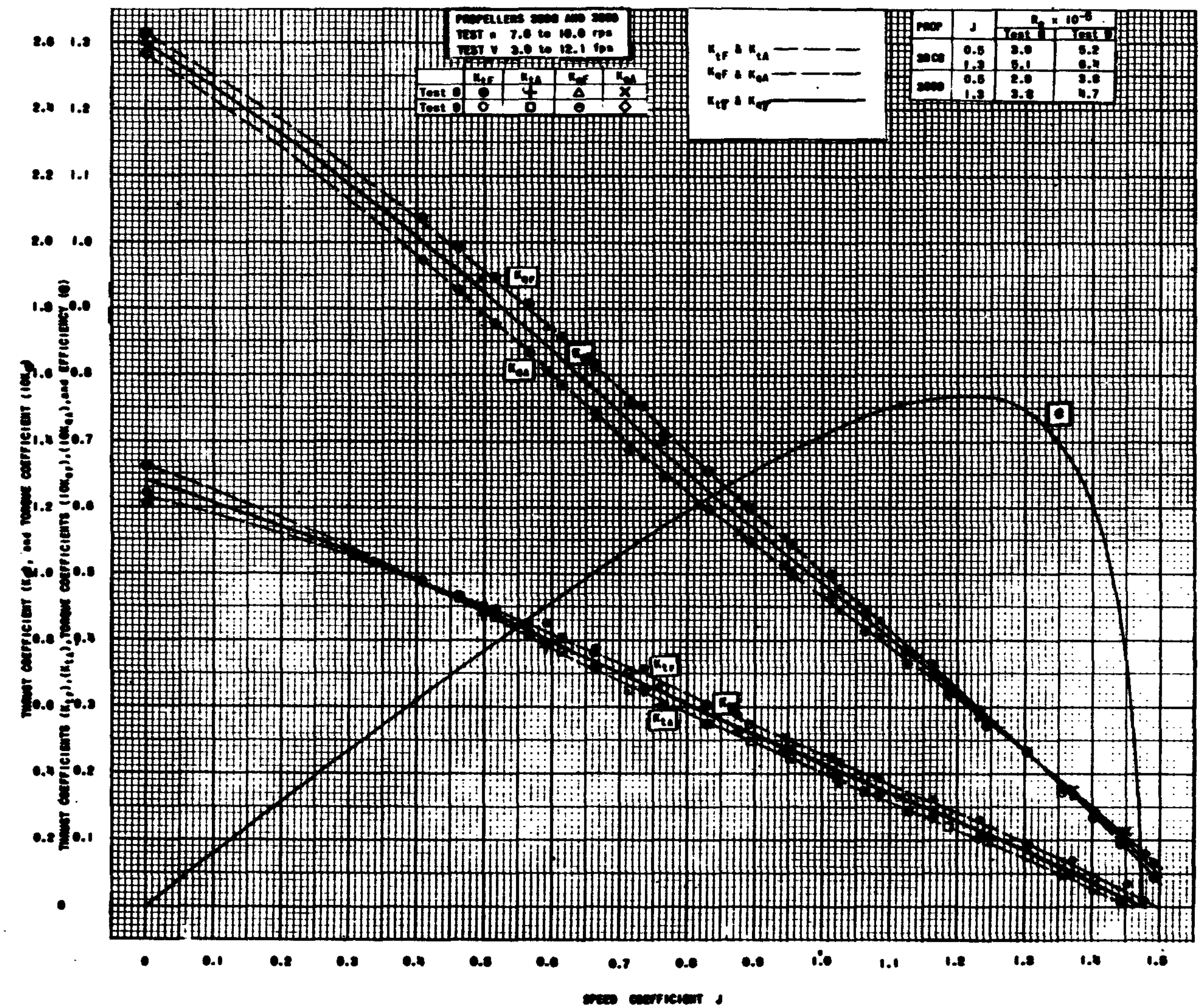


Figure 4 - Open Water Characteristics of Model Counterrotating Propellers

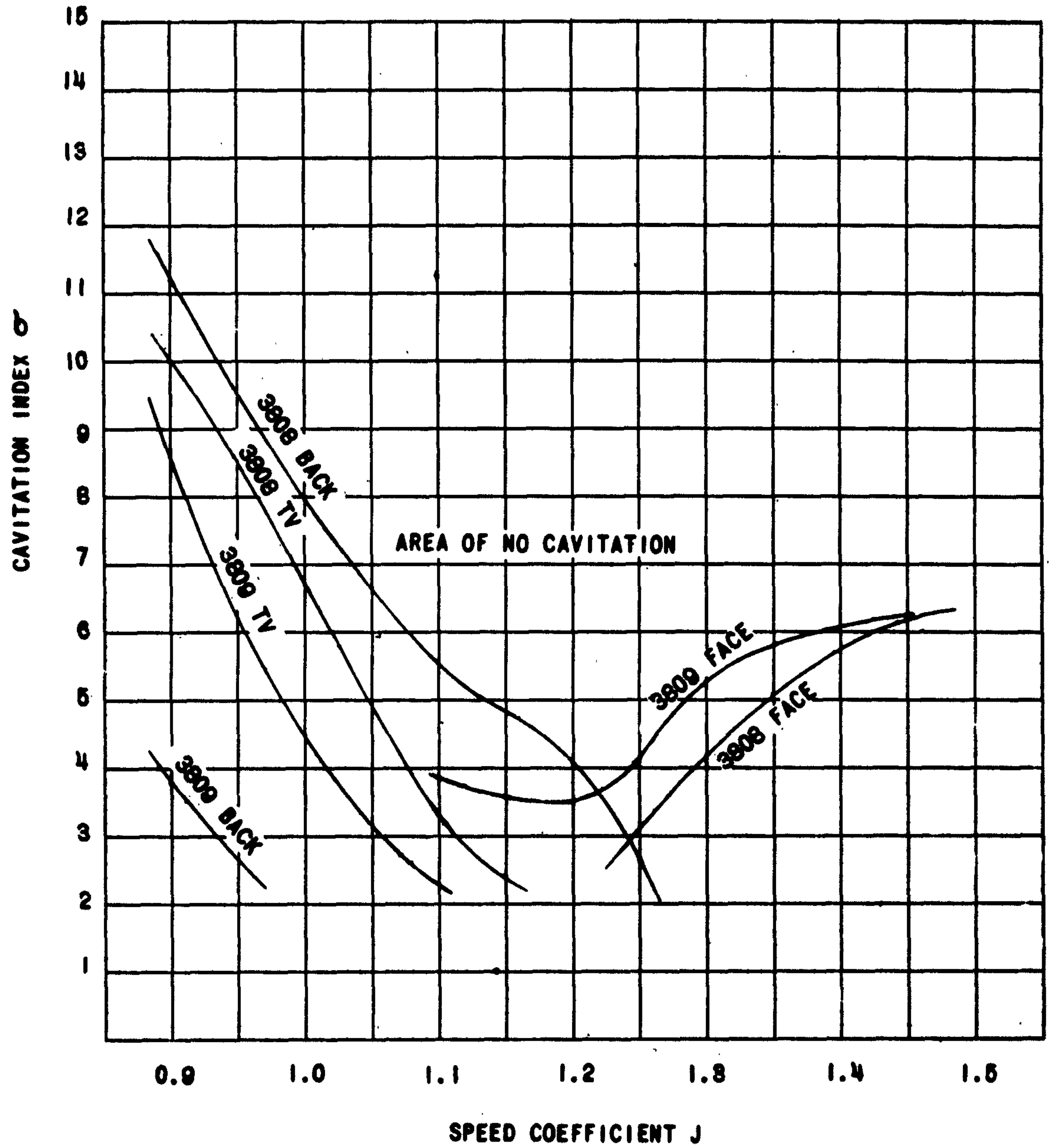


Figure 5 - Inception Curves of Visible Cavitation on Model Counterrotating Propellers

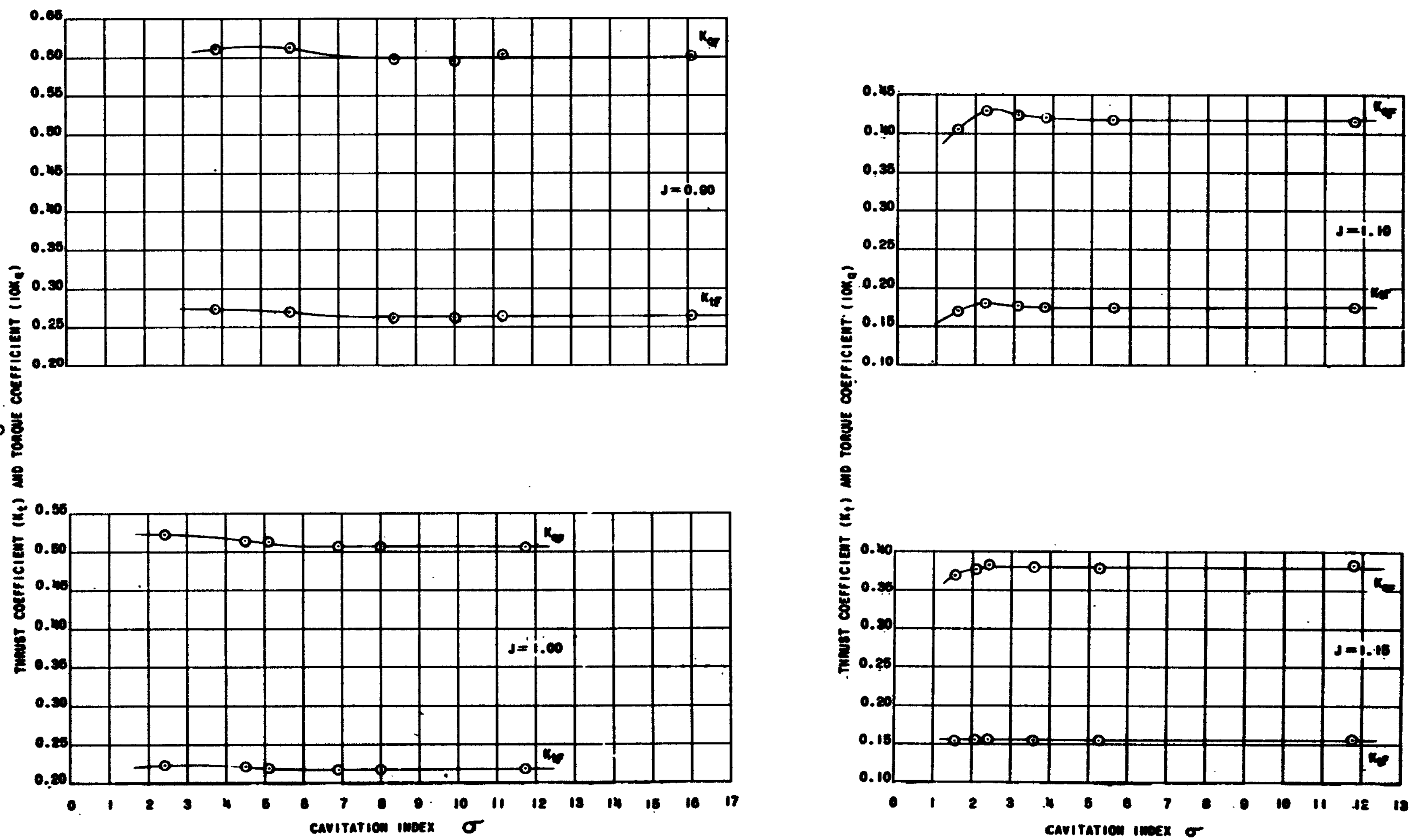


Figure 6a - Cavitation Characteristic Curves of Forward Model Counterrotating Propeller 3808

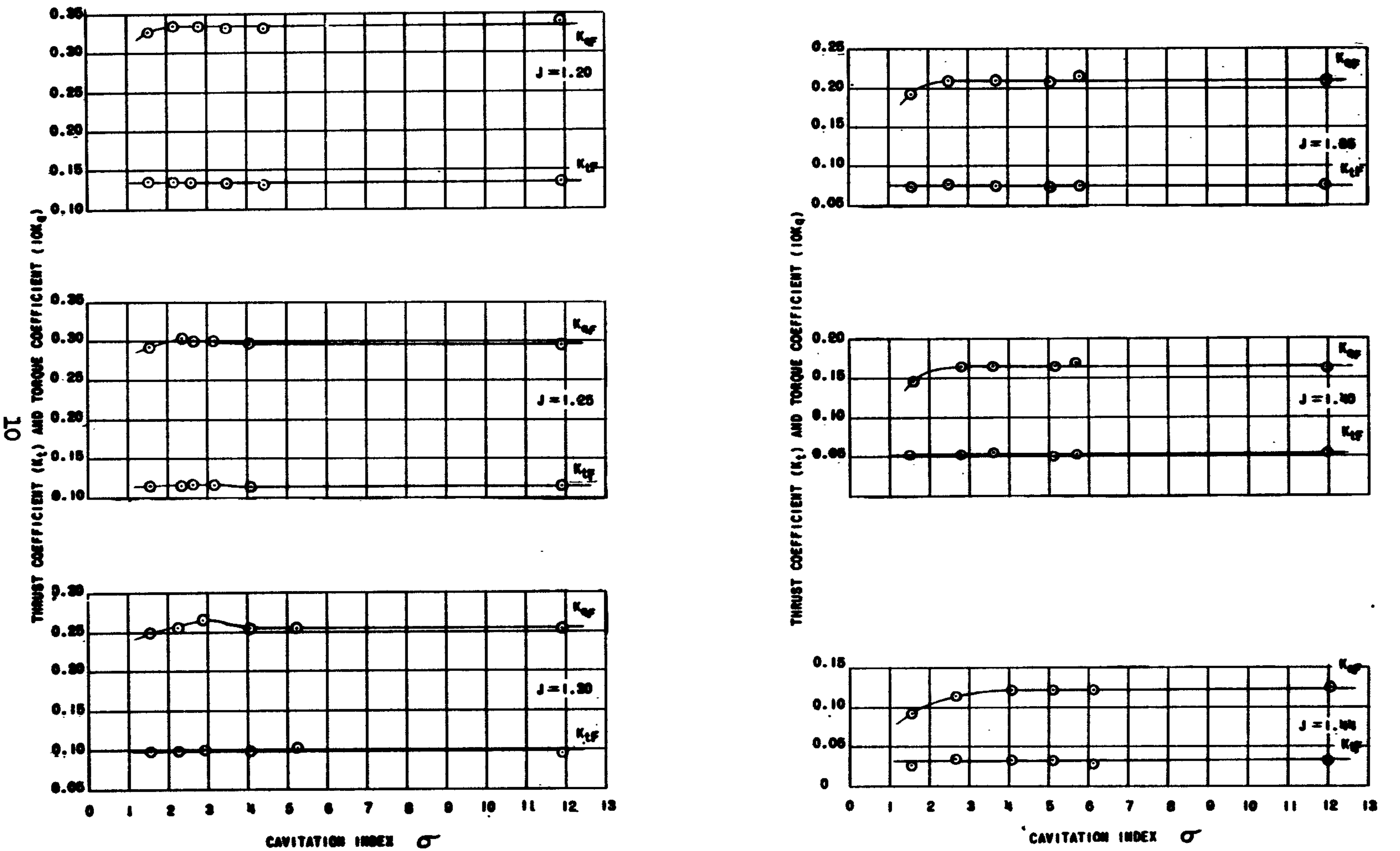


Figure 6b - Cavitation Characteristic Curves of Forward Model Counterrotating Propeller 3808

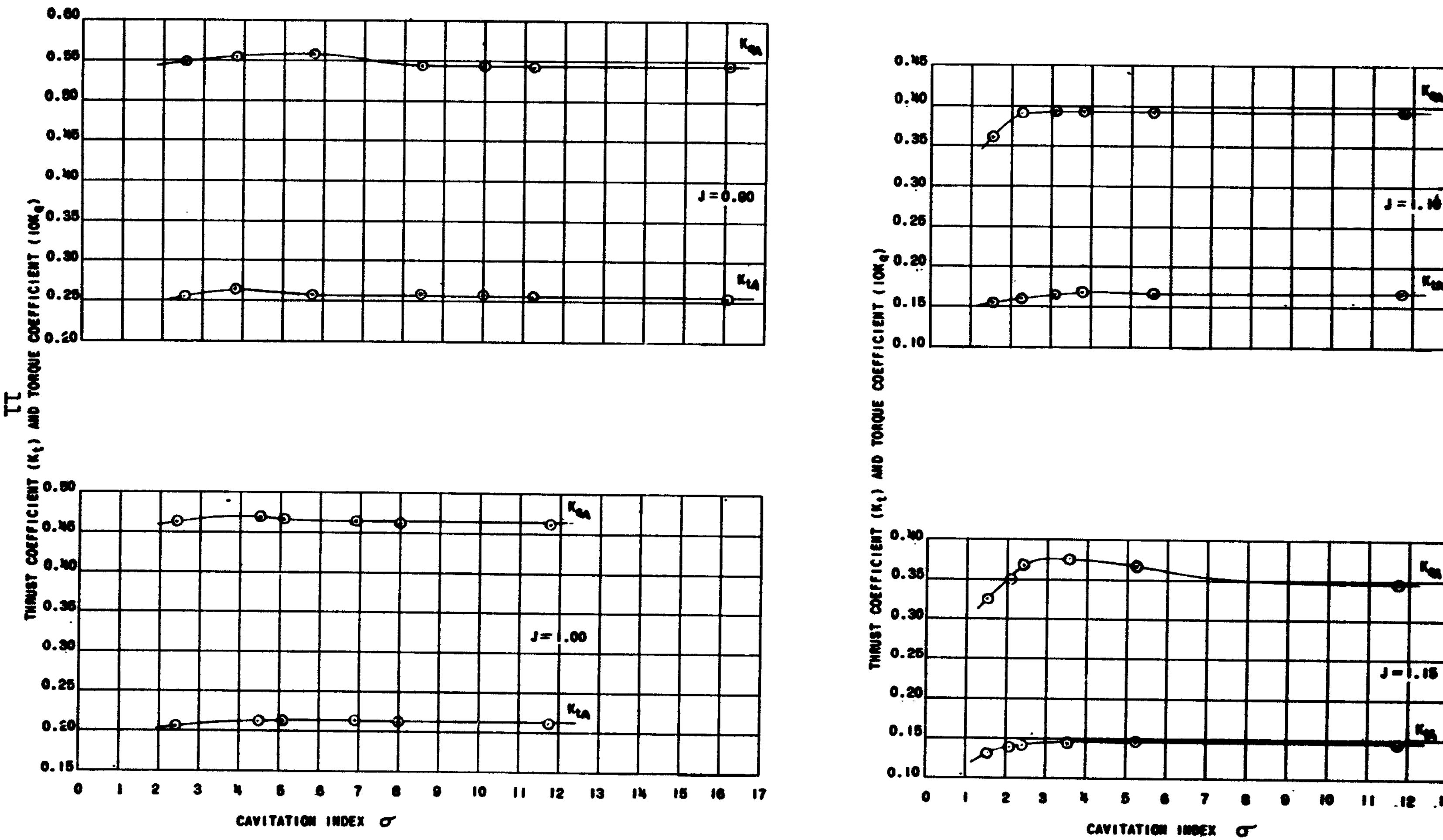


Figure 7a - Cavitation Characteristic Curves of After Model Counterrotating Propeller 3809

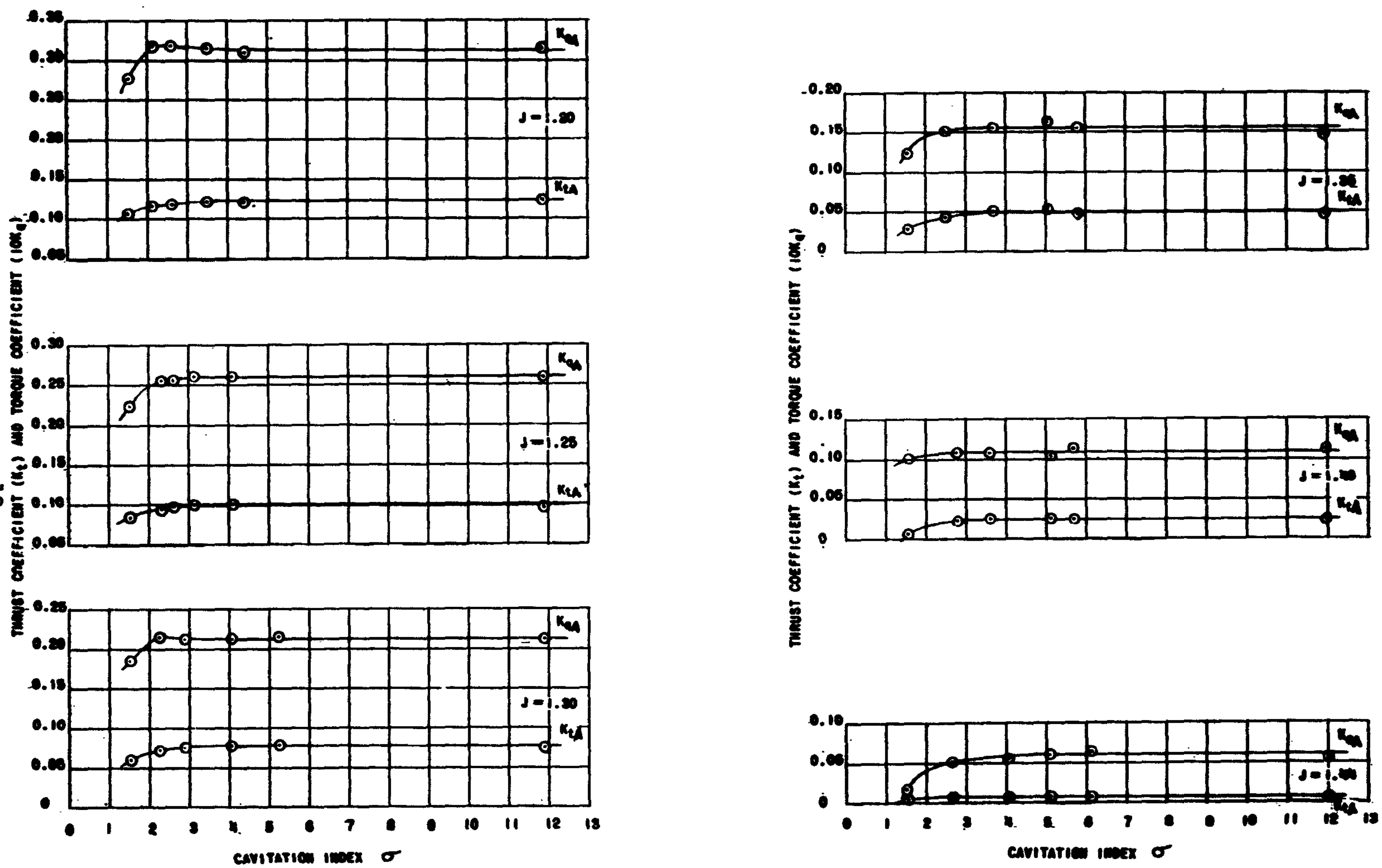
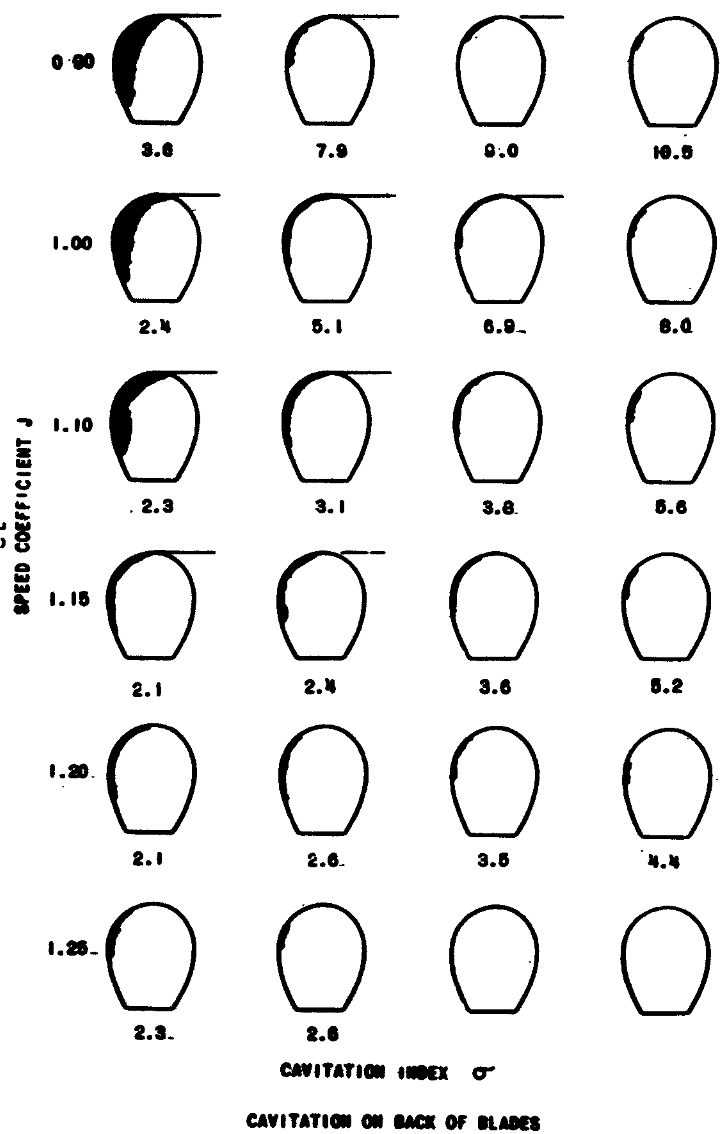


Figure 7b - Cavitation Characteristic Curves of After Model Counterrotating Propeller 3809



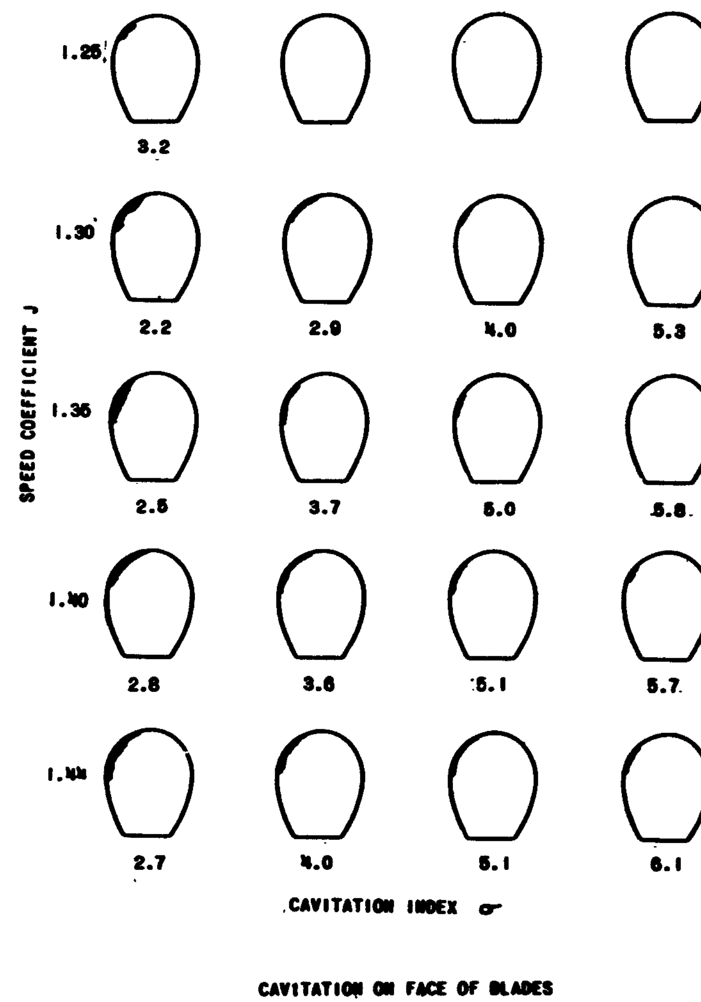


Figure 8 - Sketches of Cavitation on Forward Model Counterrotating Propeller 3808

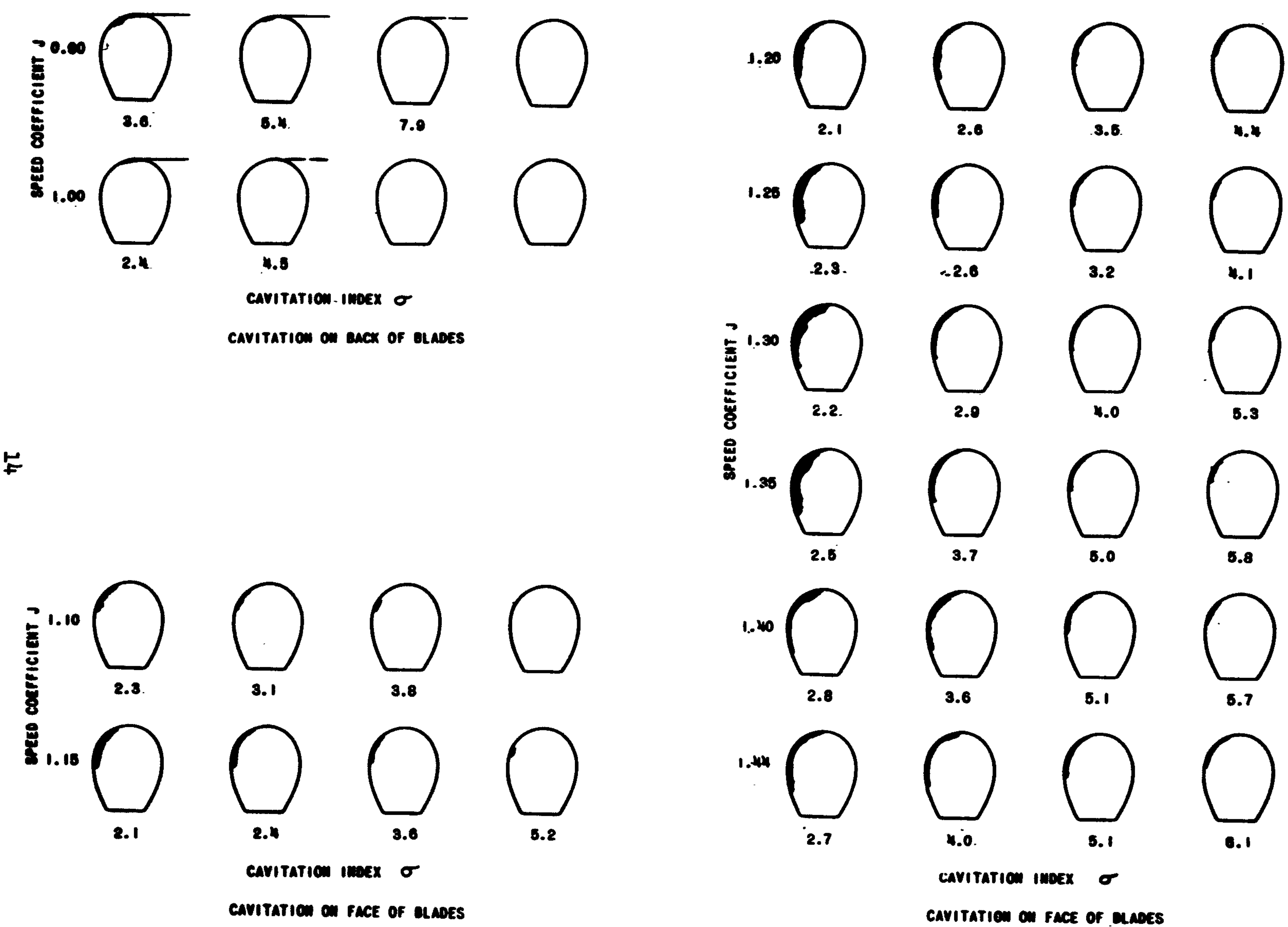


Figure 9 - Sketches of Cavitation on After Model Counterrotating Propeller 3809

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1. Counterrotating propellers--Cavitation--Test results
2. Propellers--Testing
3. Propeller models--Model TMB 3808-3809
I. Peck, James G.
II. S-F013 08 04

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